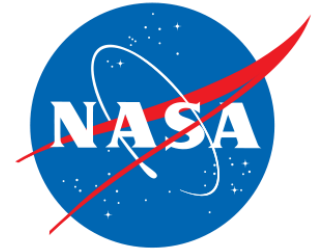


National Aeronautics and Space Administration



A Catalog of NASA-Related Case Studies

Compiled by the Office of the Chief Knowledge Officer
Goddard Space Flight Center, NASA



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Academy of Program/Project & Engineering Leadership (APPEL), NASA

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NASA Safety Center (NSC)

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Harvard Business Review

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Center for Systems Engineering, Air Force Institute of Technology

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Case Title	Atlas Centaur-67: Go or No Go for Launch?
Project Name	AC-67
Source	Office of the Chief Knowledge Officer (OCKO), NASA/GSFC
URL	http://library.gsfc.nasa.gov/public/casestudies.htm
# of Pages	3
Abstract	Thunderstorms are building near the launch facility at Cape Canaveral, Florida, when countdown commences for the Atlas Centaur-67 mission. Prior to AC-67, with its military communications satellite payload, the Atlas Centaur rocket had been deployed in 66 consecutive NASA missions. The launch team debates ambiguous weather and safety launch criteria as problems with communications equipment, and a small launch window for an eager customer, complicate the go/no-go decision in the final moments of countdown.
Subject Focus	Launch decision
Learning Points	The importance of understanding the origin and context of safety requirements. When operating near the limit of specifications, extra caution needs to be added if the requirements are not well understood. If things look really bad, they might be really bad. How to speak up in a fast-paced, high pressure environment (launch).
Other Resources	Christian, H. J., V. Mazur, B. D. Flsher, L. H. Ruhnke, K. Crouch, and R. P. Perala (1989), The Atlas/Centaur Lightning Strike Incident, J. Geophys. Res., 94(D11), 13,169–13,177.

Case Title	Building the Team: The Ares I-X Upper Stage Simulator
Project Name	ARES
Source	Academy of Program/Project & Engineering Leadership (APPEL), NASA
URL	http://www.nasa.gov/pdf/352126main_Ares_I-X_Case_Study.pdf
# of Pages	10
Abstract	The opportunity to build a new launch vehicle that can lift humans into space does not come along often. The Ares family of launch vehicles, conceived in response to the Vision for Space Exploration, presented the first chance for NASA engineers to get hands-on experience designing and building human spacecraft hardware since the development of the Space Shuttle thirty years ago. In 2005, NASA Headquarters solicited proposals from Integrated Product Teams for different segments of the Ares I-X test flight vehicle. A team at Glenn Research Center won the bid for the job of building the Ares I-X Upper Stage Simulator (USS). A fabrication job of this size required not only renovation of some facilities but also putting a team together with the right mix of skills.
Subject Focus	expertise; facilities renovation; large scale fabrication; staffing; retraining
Learning Points	The organizational context of a NASA center can determine the types of challenges faced by a project manager; Project leaders may be required to employ a number of strategies and tactics to adjust the composition of the team in order to get to the right results; professional development activities may play a key role in the makeup of the final team?.
Other Resources	http://spaceflightsystems.grc.nasa.gov/LaunchSystems/Simulator/ http://askmagazine.nasa.gov/pdf/pdf34/NASA_APPEL_ASK_34s_building_the_team.pdf

Case Title	Columbia's Final Mission
Project Name	STS-107
Source	Harvard Business Review
URL	http://hbr.org/product/columbia-s-final-mission/an/304090-PDF-ENG?Ntt=columbia
# of Pages	33
Abstract	Describes the 16-day final mission of the space shuttle Columbia in January 2003 in which seven astronauts died. Includes background on NASA and the creation of the human space flight program, including the 1970 Apollo 13 crisis and 1986 Challenger disaster. Examines NASA's organizational culture, leadership, and the influences on the investigation of and response to foam shedding from the external fuel tank during shuttle launch.
Subject Focus	shuttle accident; decision-making; communication; crisis management;
Learning Points	To analyze the flawed response to an ambiguous but potentially threatening signal during a period in which recovery of the shuttle was possible. (Source: HBR)
Other Resources	Remembering Columbia (NASA History website): http://history.nasa.gov/columbia/index.html

Case Title	Cover Blown - The WIRE Spacecraft Mishap
Project Name	WIRE
Source	NASA Safety Center (NSC)
URL	http://pbma.nasa.gov/docs/public/pbma/images/msm/WIRE_SFCS.pdf
# of Pages	4
Abstract	<p>Launched on March 4, 1999, the Wide-Field Infrared Explorer (WIRE) carried an infrared telescope that was meant to study the formation of galaxies. To prevent the satellite's heat from interfering with faint infrared signals, the telescope was stored in a cryostat cooled by tanks of frozen hydrogen. Approximately twenty minutes after WIRE separated from its launch vehicle, a transient electronic signal released the cryostat cover, exposing the hydrogen tanks to heat from the sun and earth. The hydrogen sublimated and escaped through the vents, sending the spacecraft into an uncontrolled spin. In less than thirty-six hours, the entire four-month supply of solid hydrogen needed to cool the telescope's infrared sensors was gone.</p>
Subject Focus	on-orbit failure; test-as-you-fly; peer reviews
Learning Points	Underlying issues identified by the Mishap Investigation Board (MIB) included the following: 1) Failure to consider off-nominal conditions; 2) Lack of peer reviews; 3) Incomplete test procedures and analysis.
Other Resources	Listed at the end of the case study document

Case Title	Earth Observing System Data Information System (EOSDIS)
Project Name	EOSDIS
Source	Academy of Program/Project & Engineering Leadership (APPEL), NASA
URL	http://www.nasa.gov/pdf/384155main_EOSDIS_case_study.pdf
# of Pages	35
Abstract	The Earth Observing System Data and Information System (EOSDIS) was started as part of the Earth Observing System (EOS). This system was meant to collect, process, distribute, and archive the large amount of data that was to be generated by the EOS program and to archive and distribute NASA Earth science data. The purpose of this case study on EOSDIS is to help NASA managers, engineers, and scientists understand what happened during the implementation of the EOSDIS in order to be able to apply the lessons learned to future programs and projects.
Subject Focus	R&D environment vs. operational environment; developers vs. users; instability of requirements; acquisition strategy
Learning Points	1) Don't overreact or let the pendulum swing too far in the other direction; 2) Know what you want to build and be able to define it; 3a) Acquisition strategy must be tailored to any system where the user needs are difficult to articulate and subject to technological evolution and enhancement; 3b) A build-it-by-the-yard approach is desirable to maintain cost control while allowing flexibility for evolutionary changes; 3c) Flexible options must be available for the outer concentric developments; 4) Control expectations; tell the truth about capabilities; 5) Choose the appropriate organizational structure, staff it accordingly, and stay with it; 6) Keep the flight operating system (FOS) tied to the flight segment; 7) A strong systems engineering capability is needed for large, complex system development; 8) If the underlying processes are not in place, you don't have a chance; 9) Program, Project, and executive leadership must be aware of the environment; 10) Strong leadership, at all levels, is critical to the development of a new, complex, highly-visible system; 11) Maintaining partnerships between the teams is necessary for a successful development; 12) A large government program with high visibility draws political attention that can impact development; 13) Endless reviews do not help a struggling project.
Other Resources	References are listed at the end of the case document.

Case Title	Fender Bender - DART's Automated Collision
Project Name	DART
Source	NASA Safety Center (NSC)
URL	http://pbma.nasa.gov/docs/public/pbma/images/msm/DART_SFCS.pdf
# of Pages	4
Abstract	The Demonstration of autonomous Rendezvous Technology (DART) program intended to demonstrate that a spacecraft could independently rendezvous with an orbiting satellite without human intervention. The DART spacecraft was successfully launched in April 2005. Following a series of navigational system errors and problems with fuel management, DART crashed into its rendezvous partner spacecraft.
Subject Focus	navigational system error; on-orbit failure
Learning Points	Underlying issues included 1) Flawed software requirements and validation approach; 2) Ineffective design choices, and; 3) lack of training, experience and oversight. The mission illustrated the importance of independent assessments, audits, and peer reviews throughout the various stages of a mission.
Other Resources	Listed at the end of the case study document.

Case Title	Final Voyage of the Challenger
Project Name	STS-51L
Source	Harvard Business Review
URL	http://hbr.org/product/final-voyage-of-the-challenger/an/691037-PDF-ENG
# of Pages	35
Abstract	On January 28, 1986, seven astronauts were killed when the space shuttle they were piloting, the Challenger, exploded just over a minute into the flight. The failure of the solid rocket booster O-rings to seat properly allowed hot combustion gases to leak from the side of the booster and burn through the external fuel tank. The failure of the O-ring was attributed to several factors, including faulty design of the solid rocket boosters, insufficient low- temperature testing of the O-ring material and the joints that the O-ring sealed, and lack of proper communication between different levels of NASA management. The case "provides a summary of technical and organizational details that led to the decision to launch the Challenger Space Shuttle, and to the ensuing accident.
Subject Focus	shuttle accident; decision-making; risk management
Learning Points	Details of design and testing milestones of the Space Shuttle, with a focus on the Solid Rocket Booster, offer opportunities for project management and organizational analysis. NASA's risk management structure and its use for the Space Shuttle program exposes students to issues of risk associated with the use of technology. Principles of engineering versus managerial decision making, the role of professional knowledge, and issues related to data representation, and qualitative versus quantitative analysis are addressed. Some issues of professional ethics and individual responsibilities, as related to complex decision making in a technology intensive environment are presented in a context of a crisis situation. The analysis of the case should include assessment of project management, and ideas about organizational changes to avoid recurrence." (Source: HBR website)
Other Resources	STS-51L Challenger Accident (NASA History website): http://history.nasa.gov/sts51l.html

Case Title	Fire in the Cockpit - The Apollo 1 Tragedy
Project Name	Apollo 1
Source	NASA Safety Center (NSC)
URL	http://pbma.nasa.gov/docs/public/pbma/images/msm/Apollo_SFCS.pdf
# of Pages	4
Abstract	A seminal event in the history of human spaceflight occurred on the evening of January 27th, 1967, at Kennedy Space Center (KSC) when a fire ignited inside the Apollo 204 spacecraft during ground test activities. The 100% oxygen atmosphere, flammable materials and a suspected electrical short created a fire that quickly became an inferno. Virgil Grissom, Edward White II, and Roger Chaffee (the prime crewmembers for Apollo mission AS-204 -- later designated Apollo 1) perished in the flames before the hatch could be opened.
Subject Focus	design and material issues; quality control; emergency preparedness; budget and schedule pressures; complacency
Learning Points	The Apollo 1 case study is particularly important for NASA to consider in development of designs for the Orion spacecraft and Ares family of booster rockets. The Apollo 1 case demonstrates how previous success with a recognized, but not properly mitigated condition, can lull managers, designers and operators into complacency. The case also underscores the need to understand material properties across the full range of operating environments. Finally, the case illustrates how solutions to one problem can become the source of new problems.
Other Resources	Listed at the end of the case study document

Case Title	GOES-N: Long and Winding Road to Launch
Project Name	GOES-N
Source	Office of the Chief Knowledge Officer (OCKO), NASA/GSFC
URL	http://library.gsfc.nasa.gov/public/casestudies.htm
# of Pages	8
Abstract	GOES-N was built to be the most advanced meteorological satellite in space, the first in the next generation of “geostationary operational environmental satellites.” Getting GOES-N into orbit is proving to be extremely difficult. For months in 2005-06, during a string of delays and resets due to lightning strikes to the rocket and strikes by contractor technicians, the satellite has sat on the pad while project managers wrestle with launch issues: on-ground duration without systems retesting, whether to de-stack, and when an observatory and spacecraft have been on the launch pad too long.
Subject Focus	Managing fixed-price contract; technical role in launch decision; managing exigencies
Learning Points	The role of the Systems Engineer to marshal the project towards launch. How engineering (technical) issues spill over into procurement (contract) issues. Implications of a fixed price delivery contract for space missions and launch services. Making judgment calls on equipment readiness.
Other Resources	GOES-N Web page: http://www.nasa.gov/mission_pages/goes-n/main/

Case Title	Gravity Probe B
Project Name	GP-B
Source	Academy of Program/Project & Engineering Leadership (APPEL), NASA
URL	http://www.nasa.gov/pdf/384132main_Gravity_Probe_B_case_study.pdf
# of Pages	11
Abstract	In the summer of 2003, NASA Program Manager Rex Geveden was eager to ship the Gravity Probe B (GP-B) spacecraft to Vandenberg Air Force Base for integration and testing and then launch. In April the program had undergone a termination review, which in Geveden's estimation, had been a close call. Getting the spacecraft to the launch pad would remove the threat of imminent cancellation. After the spacecraft arrives at Vandenberg, problems with the Experimental Control Unit (ECU) are identified. Will these problems require the launch to be postponed until the issues are satisfactorily addressed?
Subject Focus	schedule pressures; launch decisions; risk management; risk mitigation
Learning Points	Different types of pressures can affect the behavior of key stakeholders. Different stakeholders can characterize anomalies differently in risk management terms. Various organizational and managerial factors can complicate the decision-making process for the program manager.
Other Resources	Gravity Probe B website at Stanford University: http://einstein.stanford.edu/ ; NASA Mission Page: http://www.nasa.gov/mission_pages/gpb/index.html

Case Title	Hubble Space Telescope: Systems Engineering Case Study
Project Name	HUBBLE
Source	Center for Systems Engineering, Air Force Institute of Technology
URL	http://www.afit.edu/cse/csdl.cfm?case=18&p=0&file=Hubble SE Case Study.pdf
# of Pages	69
Abstract	This is a full length case exploring in depth the systems engineering challenges of building the Hubble Space Telescope. The issue of the mirror is dealt with and why it was missed in development and build. The case explains the various instruments and has detailed photos and charts. References are made to the NASA systems engineering guidebook which has since been updated.
Subject Focus	Systems Engineering
Learning Points	Early and full participation of customer is essential. Pre-program trade studies can help keep early discussions focused on technical considerations when political concerns are trying to play with the project. Systems integration and testing need to be a significant portion of program resources. Life cycle support is critical from day one. Number of players introduces risk that needs to be addressed.
Other Resources	Hubble website: http://hubble.nasa.gov/

Case Title	IBEX: Managing Logistical Exigencies
Project Name	IBEX
Source	Office of the Chief Knowledge Officer (OCKO), NASA/GSFC
URL	http://library.gsfc.nasa.gov/public/casestudies.htm
# of Pages	1
Abstract	The Interstellar Boundary Explorer (IBEX) will provide images that will reveal properties of the interstellar boundaries that separate our heliosphere from the local interstellar medium. When the time comes to move IBEX and its attached rocket assembly the 15 miles to the launch pad, it becomes obvious that it will not fit in the moving container. The fall-back—double-bagging the assembly in plastic—is for much shorter trips. Numerous risks are considered.
Subject Focus	Logistics, communication
Learning Points	Just because it says somewhere it can be done, doesn't mean that it's the right thing to do. How can a safety officer push back and get support for an unpopular but safety first decision? The responsibility to protect flight hardware.
Other Resources	IBEX website: http://ibex.swri.edu/

Case Title	IMAGE
Project Name	IMAGE
Source	Academy of Program/Project & Engineering Leadership (APPEL), NASA
URL	http://www.nasa.gov/flash/293122main_image_study.swf
# of Pages	n/a – self-learning multimedia presentation
Abstract	In this interactive case study you will be presented with a real management situation faced by the NASA-contracted Southwest Research Institute team during the groundwork of the Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) mission. As the Project Manager you will need to respond in the most effective and timely manner possible. Your decision will directly affect the outcome of the entire mission. When faced with the following problems, you will want to respond as a Project Manager and to think about ways that you can encourage your team to do the same.
Subject Focus	budget; schedule; science; team; project management
Learning Points	
Other Resources	IMAGE Mission website: http://image.gsfc.nasa.gov/

Case Title	International Project Management: The Cassini-Huygens Mission
Project Name	CASSINI-HUYGENS
Source	Academy of Program/Project & Engineering Leadership (APPEL), NASA
URL	http://www.nasa.gov/offices/oce/appel/knowledge/publications/cassini.html
# of Pages	14 (slides)
Abstract	The Cassini-Huygens Mission is a United States/European mission to explore the ringed planet. NASA and the Italian Space Agency developed the Cassini spacecraft, and the European Space Agency (ESA) designed and built the Huygens probe. Cassini-Huygens was launched October 1997 on a 6.7-year voyage to Saturn. A failure in Cassini's telemetry system as the spacecraft approached Saturn, after a multi-year journey through deep space, posed a critical problem for the mission management team.
Subject Focus	on-orbit failure,; telemetry; international collaboration; ITAR
Learning Points	This NASA mini-Case Study looks at the programmatic and technical complexities of an international deep-space mission in which there is zero room for error. It elucidates some of the mission's primary challenges and their solutions.
Other Resources	Cassini Equinox Mission (JPL website): http://saturn.jpl.nasa.gov/ Cassini-Huygens (ESA website): http://www.esa.int/SPECIALS/Cassini-Huygens/index.html

Case Title	Launching New Horizons: The RP-1 Tank Decision
Project Name	New Horizons
Source	Academy of Program/Project & Engineering Leadership (APPEL), NASA
URL	http://www.nasa.gov/pdf/337384main_New_Horizons_RP1_Tank_Case_Study.pdf
# of Pages	16
Abstract	Four months before the planned launch of the New Horizons mission to Pluto (scheduled for January 2006), the manufacturer of the launch vehicle reported that its fuel tank experienced a failure during the final stages of qualification testing. The questions raised by this failure ultimately presented a test case for the agency's recently revamped governance model. The programmatic, engineering, and safety communities had fundamental disagreements about difficult technical questions, which ultimately led to an appeal to the NASA Administrator.
Subject Focus	governance model; independent technical authority; transparent decision making
Learning Points	One of the most vigorous and healthy discussions at NASA over the past several years has concerned the establishment of the formal process for ensuring that dissenting opinions receive a full and fair hearing. That process, now codified in NASA Procedural Requirement (NPR) 7120.5D: NASA Space Flight Program and Project Management Requirements, applies to unresolved issues of any nature (technical, programmatic, safety, or other), and delineates an orderly way of raising difficult issues and, when necessary, elevating them to higher levels of management for resolution.
Other Resources	NASA Mission page: http://www.nasa.gov/mission_pages/newhorizons/main/index.html

Case Title	Launching the Vasa
Project Name	VASA
Source	Office of the Chief Knowledge Officer (OCKO), NASA/GSFC
URL	http://library.gsfc.nasa.gov/public/casestudies.htm
# of Pages	8
Abstract	The 17th-century warship Vasa sank upon launch with great loss of life owing to many political, and engineering development factors. This lessons from this historic example are used as a prescriptive warning for large projects like ESMD.
Subject Focus	Risk mgt., communication, culture conflict, new technology, requirements issues, cost-schedule mgt.
Learning Points	Define risks in actionable ways. What everyone knows but no-one says can doom a project in subtle ways. Know what your test means and what success means before you conduct the test. Stick by the results of your test. Getting risks identified is the way to get them discussed.
Other Resources	VASA Museum website: http://www.vasamuseet.se/en/ ; Famous Failures: The VASA (PPT): www.cs.huji.ac.il/course/2003/postPC/docs/Famous_Failures_Vasa.ppt

Case Title	Lewis Spins out of Control
Project Name	Lewis
Source	NASA Safety Center (NSC)
URL	http://pbma.nasa.gov/docs/public/pbma/images/msm/lewis1_sfcs.pdf
# of Pages	4
Abstract	<p>The Lewis Spacecraft Mission was conceived as a demonstration of NASA's Faster, Better, Cheaper (FBC) paradigm. Lewis was successfully launched on August 23, 1997, from Vandenberg Air Force Base, California on a Lockheed Martin Launch Vehicle (LMLV-1). Over the next three days a series of on-orbit failures occurred including a serious malfunction of the attitude control system (ACS). The ACS issues led to improper vehicle attitude, inability to charge the solar array, discharge of batteries, and loss of command and control. Last contact was on August 26, 1997. The spacecraft re-entered the atmosphere and was destroyed 33 days later. This mission may have been faster and cheaper, but in retrospect it was at the expense of better.</p>
Subject Focus	Faster, Better, Cheaper (FBC); on-orbit failure
Learning Points	<p>Weak project management, a poorly articulated approach (FBC), and poor hardware/software verification can all lead to project failure. The NASA Lewis spacecraft serves as a cautionary tale for those proposing radical cost saving or cycle-time reduction techniques in complex space programs.</p>
Other Resources	<p>NASA Lewis Mishap Investigation Report (121998) NASA. http://space.se.spacegrant.org/Failure%20Reports/Lewis_MIB_2-98.pdf</p>

Case Title	Lifting NOAA-N Prime
Project Name	NOAA-N PRIME
Source	Office of the Chief Knowledge Officer (OCKO), NASA/GSFC
URL	http://library.gsfc.nasa.gov/public/casestudies.htm
# of Pages	4
Abstract	NOAA-N PRIME was one of a series of polar-observing satellites used for weather prediction. While being rotated (vertical to horizontal) on a turnover cart for a routine procedure in the builder's facility the satellite fell off the cart, sustaining significant and costly damage. Complacency and poor management, planning, communication, and procedures contributed to a mishap that easily could have been avoided.
Subject Focus	Risk management, communication, organizational silence, contractor issues
Learning Points	<ul style="list-style-type: none"> • Lax observance and control of even the most mundane, standardized procedures can have devastating consequences. • Safety and asset management always trump potential cost and schedule savings resulting from using unconventional or hasty procedures. • An organizational environment allowing for a "we do this all the time" modus operandi is a pretext for disaster. • Oversight of joint projects is every manager's first priority, whether contractor or government agency. • There is no substitute for onsite, visual inspection and verification. • Ignore at your peril engineering input from any level.
Other Resources	Mishap Investigation Board Report: URL: http://www.nasa.gov/pdf/65776main_noaa_np_mishap.pdf ; NOAA-N PRIME website: http://www.nasa.gov/mission_pages/NOAA-N-Prime/main/index.html

Case Title	Lost in Translation - The Mars Climate Orbiter Mishap
Project Name	Mars Climate Orbiter (MCO)
Source	NASA Safety Center (NSC)
URL	http://pbma.nasa.gov/docs/public/pbma/images/msm/MCO_SFCS.pdf
# of Pages	4
Abstract	The signal from NASA's Mars Climate Orbiter disappeared on Thursday, September 23, 1999. After a nine-month journey from earth, the spacecraft was moving into orbit around Mars when communications stopped. Ground software had miscalculated the spacecraft's trajectory. Instead of lightly skimming the Martian atmosphere, the spacecraft was orbiting more than 170 kilometers below its target altitude. Heat and drag from the atmosphere presumably destroyed the satellite.
Subject Focus	spacecraft trajectory; ground software
Learning Points	The proximate cause of the failure was a discrepancy between the use of English units vs. metric units in treating data from the ground navigation software. Underlying issues included the following: 1) the software interface control process and interface verification were not sufficiently rigorous; 2) communication between project elements was deficient; 3) the operations navigation team was unprepared, oversubscribed, and operating based on limited understanding of the MCO's specific design.
Other Resources	Listed at the end of the case study document

Case Title	Mechanical Systems Engineering Support Contract Re-Compete
Project Name	MSES
Source	Office of the Chief Knowledge Officer (OCKO), NASA/GSFC
URL	http://library.gsfc.nasa.gov/public/casestudies.htm
# of Pages	4
Abstract	Competitive procurement for providing mechanical, thermal, and other engineering services to Goddard's Applied Engineering and Technology Directorate in support of space technology development, Earth and Space Science missions, and NASA's Exploration Program resulted in a \$400 million contract award, replacing the contractor in place for 25 years. This case looks at the very difficult contracting process and litigious aftermath that ultimately ended in success.
Subject Focus	culture conflict, contracts, contractors, communication
Learning Points	Responsibility to Government procurement policy and procedures, where does Government responsibility end in meeting procurement policy goals? How can Government procurement affect mission success now and in the future through unintended consequences relating to capabilities and workforce development. Thinking strategically in procurement, planning ahead, avoiding hostage situations.
Other Resources	

Case Title	NEAR (Near Earth Asteroid Rendezvous)
Project Name	NEAR
Source	Academy of Program/Project & Engineering Leadership (APPEL), NASA
URL	http://www.nasa.gov/flash/293123main_near_study.swf
# of Pages	n/a – self-learning multimedia presentation
Abstract	<p>It's 1995. You're the Johns Hopkins University APL Project Manager and have been contracted by NASA for the NEAR mission. Near's Critical Design Review (CDR) has already passed, and everything's been designed and coded. You're right on target to meet the lofty goal of launching the spacecraft only 27 months from the mission's inception. Suddenly, you find out that a change to the mission has been proposed; several team members want you to make a modification to the mission's XGRS instrument. They want this change because it would allow the NEAR mission to collect data on gamma ray bursts. They propose that you modify the software, the hardware, or both. But changing any of the hardware or software at this late stage in the project would have an impact on the science, the schedule, the budget, and the team. What are you going to do? What will you need to know to make your decision?</p>
Subject Focus	redesign; managing change
Learning Points	
Other Resources	

Case Title	Pegasus XL-HESSI: Last-Minute Decisions in Flight-Based Launch
Project Name	HESSI
Source	Office of the Chief Knowledge Officer (OCKO), NASA/GSFC
URL	http://library.gsfc.nasa.gov/public/casestudies.htm
# of Pages	8
Abstract	The High Energy Solar Spectroscopic Imager (HESSI), a flight-based launch on a Pegasus rocket, was designed to provide high-resolution imaging of solar flares, which can damage satellites, radio communications, and power grids on Earth. Flight-based launches are dynamic, often hectic events for launch teams. The Pegasus XL-HESSI launch demonstrates why communication dropouts and a critical technical issue are still being debated during final countdown for a brief launch window.
Subject Focus	Launch decision, communication, risk mgt.
Learning Points	Manage 'launch fever.' The pressure to launch is immense the closer to the date. Understand the importance of pre-agreed criteria, what is critical and what is not. How a launch decision or scrub is made in real time. Slowing down for a caution sometimes means you will get stuck at the light.
Other Resources	HESSI web page: http://hesperia.gsfc.nasa.gov/hessi/

Case Title	Redesigning the Cosmic Background Explorer
Project Name	COBE
Source	Academy of Program/Project & Engineering Leadership (APPEL), NASA
URL	http://www.nasa.gov/pdf/384131main_COBE_case_study.pdf
# of Pages	10
Abstract	COBE was slated to launch on the Shuttle in 1989 from Vandenberg Air Force Base. The Shuttle would place the satellite at an altitude of 300 kilometers, and an on-board propulsion system would then raise it to a circular 900 kilometer sun-synchronous orbit. The loss of the Space Shuttle Challenger 73 seconds after liftoff on January 28, 1986, changed everything. The Shuttle program's future was now uncertain and this had dramatic consequences across NASA, not only for the human space flight program. The COBE team was forced back to the drawing board.
Subject Focus	launch vehicle; redesign; matrix management; mass; co-location; test-as-you-fly
Learning Points	Since spacecrafts are designed based on pre-identified launch vehicles, a change in launch vehicles will likely result in a significant redesign, added costs and schedule slips. With the appropriate support at the Center level and from headquarters, financial and human resources can be applied to get things done and organizational structures can be re-aligned to fit the needs of a project. "Test as you fly" in order to catch problems before launch.
Other Resources	Cobe Satellite Marks 20th Anniversary - http://www.nasa.gov/topics/universe/features/cobe_20th.html

Case Title	Searching for Life on Mars: The Development of the Viking Gas Chromatograph Mass Spectrometer
Project Name	Viking
Source	Academy of Program/Project & Engineering Leadership (APPEL), NASA
URL	http://www.nasa.gov/pdf/384151main_Viking_GCMS_case_study.pdf
# of Pages	8
Abstract	The Viking mission was set to be the first mission to attempt a soft landing on Mars. The opportunity to conduct experiments on the planet's surface led to an extremely ambitious scientific agenda featuring thirteen scientific instruments. The primary objective of the Viking mission was to determine if there was evidence of life on Mars. In 1971, the project manager added the Gas Chromatograph-Mass Spectrometer (GCMS) to his "Top Ten Problems" list. While the project was managed from the Langley Research Center, the GCMS was the responsibility of the Jet Propulsion Lab (JPL). This arrangement failed to provide the desired results.
Subject Focus	Instrument development; project management
Learning Points	Get the right technical expertise to solve technical problems; reach out to other industries and the private sector to identify solutions (even when they are proprietary); consider using a "Top Ten Problems" list to give visibility to challenges that could threaten the viability of the mission.
Other Resources	NASA's Viking webpage: http://www.nasa.gov/mission_pages/viking/

Case Title	Shuttle Software Anomaly
Project Name	STS-126
Source	NASA Safety Center (NSC)
URL	http://pbma.nasa.gov/docs/public/pbma/images/msm/STS-126_SFCS_revised.pdf
# of Pages	4
Abstract	A few minutes after the Shuttle Endeavour reached orbit for STS-126 on November 14, 2008, mission control noticed that the shuttle did not automatically transfer two communications processes from launch to orbit configuration. While the software problems did not endanger the mission, they caught management's attention because "in-flight" software anomalies on the shuttle are rare. This case looks at what happened, the proximate cause, underlying issues, as well as implications for future NASA missions.
Subject Focus	Software anomaly; "test as you fly"; anomaly documentation
Learning Points	The STS-126 illustrates the need to ensure critical elements are embedded in design and procedures, provide sufficient training, complete rigorous end-to-end testing and verification, follow the oft-quoted mantra, "Test as you fly," and find the real causes of all anomalies.
Other Resources	

Case Title	Space-to-Space communications System
Project Name	SSCS
Source	Academy of Program/Project & Engineering Leadership (APPEL), NASA
URL	http://www.nasa.gov/pdf/384149main_SSCS_case_study.pdf
# of Pages	6 (+appendices)
Abstract	The Space-to-Space Communications System (SSCS) is a sophisticated two-way data communication system designed to provide voice and telemetry among three on-orbit systems: the Space Shuttle orbiter, the International Space Station; and the Extra Vehicular Activity Mobility Unit (EMU) (aka, the spacesuit). NASA decided to treat SSCS as an in-house development at the Johnson Space Center (JSC). Numerous organizational and technical challenges emerged over time while the project was under pressure to deliver the system for use on the Space Station. After encountering multiple failures on-orbit, the team was told to "fix it" and eventually had the time and resources to do it right.
Subject Focus	schedule pressures; testing; space communications; in-house development
Learning Points	Do it right the first time or you'll have to start over. Schedule pressures and organizational challenges can lead to band-aid fixes and equipment that isn't truly ready for flight.
Other Resources	http://www.nasa.gov/offices/oce/appel/knowledge/publications/SSCS.html

Case Title	ST5 - Miniaturized Space Technology
Project Name	ST5
Source	Office of the Chief Knowledge Officer (OCKO), NASA/GSFC
URL	http://library.gsfc.nasa.gov/public/casestudies.htm
# of Pages	4
Abstract	It was clear soon after the project began that the schedule for the ST5 (Space Technology 5) mission would be stretched regardless of how development of the complex technology proceeded, for one reason: the mission lacked a launch vehicle. Cancellation was a constant threat for a mission without an LV, and five years later, ST5—a demonstration project to test and flight-qualify innovative miniaturized technologies on three identical micro-satellites—is still in limbo, and project managers face the daily challenge of keeping the team focused on a mission whose fate is uncertain.
Subject Focus	Distributed project; communication
Learning Points	Co-location of a project development team can be integral to mission success; Integrating the entire project team into the process, particularly in the case of distributed teams, should be a primary objective of the project manager; Consistently communicating the message that everyone's contribution is critical to the mission success is important; Regularly scheduled forums and open channels of communication between project management and team members, involving as many people as possible, is essential; In projects with new and inexperienced team members, the opportunity to mentor can help achieve success; Ensuring that team members clearly understand their roles and the importance of their jobs is critical, particularly on a project experiencing extensive delays.
Other Resources	Pause and Learn brochure: http://www.nasa.gov/centers/goddard/pdf/431367main_OCKO-Pal-Brochure-Rev_noLOGO.pdf ; NASA's ST5 website: http://www.nasa.gov/mission_pages/st-5/main/index.html

Case Title	STEREO: Organizational Cultures in Conflict
Project Name	STEREO
Source	Office of the Chief Knowledge Officer (OCKO), NASA/GSFC
URL	http://library.gsfc.nasa.gov/public/casestudies.htm
# of Pages	5
Abstract	The Solar Terrestrial Relations Observatory (STEREO) mission observes solar eruptions by imaging the Sun's coronal mass ejections from two nearly identical observatories simultaneously. The STEREO team includes members from Goddard Space Flight Center (GSFC), NASA HQ, the Johns Hopkins University's Applied Physics Laboratory (APL), and universities around the world. During STEREO's formulation and early implementation, cultural differences have arisen between APL and GSFC personnel. Project management from both APL and GSFC recognize this and address the challenge in a unique fashion.
Subject Focus	Organization, institutional culture clash, communication, testing, schedule-cost mgt.
Learning Points	Teaming issues are worth addressing head on and early in the project lifecycle. Different cultures that partners bring can cause problems unless addressed and dealt with methodically like a project would deal with technical issues. Frequent attention to teaming issues can keep them from disrupting a team that spans different organizations. Clarifying roles and accepting roles is important for partnerships.
Other Resources	STEREO website: http://stereo.gsfc.nasa.gov/

Case Title	Stormy Weather: Lightning Strike on the Launch Pad
Project Name	Shuttle
Source	Academy of Program/Project & Engineering Leadership (APPEL), NASA
URL	http://www.nasa.gov/externalflash/stormy_weather/index.html
# of Pages	n/a – self-learning multimedia presentation
Abstract	
Subject Focus	Shuttle launch; decision-making
Learning Points	
Other Resources	

Case Title	TDRSS: Fixed-Cost versus Cost-Plus Contracting
Project Name	TDRSS
Source	Office of the Chief Knowledge Officer (OCKO), NASA/GSFC
URL	http://library.gsfc.nasa.gov/public/casestudies.htm
# of Pages	7
Abstract	For the Tracking and Data Relay Satellite System (TDRSS), a series of geosynchronous communications satellites tracking low Earth-orbiting satellites and relaying the data to a single U.S. ground station, NASA awarded a fixed-price, leased-services contract. Numerous problems and requirements changes critically affected cost and schedule, and communications were strained between NASA, the prime contractor, and the subs. TDRSS offers excellent insight into the costs and benefits of both fixed-price and cost-plus award-fee contracting.
Subject Focus	Cost-plus versus fixed-cost contracting, contractor issues, cost-schedule mgt., culture conflicts
Learning Points	Understand contract consequences; when the government doesn't own the asset, it doesn't control its use. Commercial priorities will take precedence over science. Contracting choices will affect project for many years so be wary of short-term contracting solutions that have lasting effects on program viability.
Other Resources	TDRSS website: https://www.spacecomm.nasa.gov/spacecomm/programs/tdrss/default.cfm

Case Title	The CALIPSO Mission: Project Management in the "PI Mode": Who's in Charge?
Project Name	CALIPSO
Source	Office of the Chief Knowledge Officer (OCKO), NASA/GSFC
URL	http://library.gsfc.nasa.gov/public/casestudies.htm
# of Pages	10
Abstract	CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations), a joint mission between NASA and the French space agency CNES, was designed as a pioneering tool for observing Earth's atmosphere. Project development has been hampered for years by a complex organizational structure, management conflicts between NASA centers, international-partnership issues, and instrument and spacecraft problems—issues that appear to require a project replan.
Subject Focus	Interagency communication, roles, relationships; ITAR and international partnerships
Learning Points	Define roles and responsibilities. Multiple centers, international partners, fixed price and cost-plus bring complexity to a project that needs addressing. Complex project structures have difficulty solving problems efficiently. Know when to push on HQ for definition and direction. Managing across borders and across contractors.
Other Resources	NASA CALIPSO website: http://www.nasa.gov/mission_pages/calipso/main/index.html

Case Title	The CEV Seat: Seeking a Semi-Custom Fit in an Off-the-Rack World
Project Name	CEV
Source	Office of the Chief Knowledge Officer (OCKO), NASA/GSFC
URL	http://library.gsfc.nasa.gov/public/casestudies.htm
# of Pages	7
Abstract	Developing a seat subsystem for the Orion crew exploration vehicle presented unique engineering challenges. With Preliminary Design Review approaching, the NASA engineer in charge of the project looked to the world of auto racing and “monster trucks” for innovation ideas, then undertook a hands-on approach to building a seat prototype
Subject Focus	contractor, requirements, engineering, schedule, review, learning
Learning Points	The innovation process of go wide in thinking, go practical in prototype and go thorough in testing. Using seemingly dissimilar fields (NASCAR) to improve NASA thinking. Challenges of parallel development when requirements are being specified on the fly in parallel iterations.
Other Resources	CEV Seat Attenuation System. URL: http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20070010702_2007005306.pdf

Case Title	The Dart Mission: Changing Environment, Shifting Priorities, Hard Decisions
Project Name	DART
Source	Office of the Chief Knowledge Officer (OCKO), NASA/GSFC
URL	http://library.gsfc.nasa.gov/public/casestudies.htm
# of Pages	6
Abstract	DART (Demonstration of Autonomous Rendezvous Technology) originated as a low-profile project to demonstrate that a spacecraft could rendezvous with a satellite without the assistance of ground control. The mission emerged, however, as NASA's "first flight demonstration of new exploration capability," the vanguard of the Vision for Space Exploration. With the high profile came high pressure. After a cost increase of more than 100 percent and schedule delays, DART failed halfway through its mission. Software development and testing in the guidance/navigation/control system, and inadequate systems engineering, were identified as causes. Could failure have been prevented?
Subject Focus	Communication, Contractors, Engineering, Instrumentation, ITAR, LV, Politics, Project Mngt, Roles, Technical, Technology, Testing
Learning Points	Understanding the context of heritage hardware and software--how to verify and assure usage as accepted. The use of Lessons Learned and the danger of relying on LL without context and continued monitoring of application. Dealing with program changes, shifting risk postures and international partners.
Other Resources	DART MIB Overview Report http://www.nasa.gov/pdf/148072main_DART_mishap_overview.pdf

Case Title	The Million Mile Rescue - SOHO Lost in Space
Project Name	SOHO
Source	NASA Safety Center (NSC)
URL	http://pbma.nasa.gov/docs/public/pbma/images/msm/SOHO_SFCS.pdf
# of Pages	4
Abstract	<p>The Solar Heliospheric Observatory Spacecraft (SOHO) is a major element of the joint ESA/NASA International Solar Terrestrial Program. Launched on December 2, 1995, it successfully completed its primary mission by 1997. After implementation of code modifications meant to increase SOHO's lifetime during its extended operations phase, multiple errors in the new command sequence repeatedly sent the spacecraft into an emergency safe mode. One key error remained undetected while ground controllers made a critical mistake based on an unconfirmed and faulty assumption. SOHO's attitude progressively destabilized until all communication was lost in the early hours of June 25, 1998. It took three months to miraculously recover and restore SOHO to full mission status.</p>
Subject Focus	in space recovery; extending the mission; ground operations
Learning Points	<p>The joint ESA/NASA Investigation Board (IB) determined that the mishap was a direct result of ground operations errors and that there were no anomalies on-board the spacecraft itself. Underlying issues included: 1) lack of change control; 2) failure to follow procedures; 3) overly aggressive task scheduling; 4) inadequate staffing and training.</p>
Other Resources	Listed at the end of the case study document

Case Title	The Pursuit of Images of Columbia
Project Name	COLUMBIA
Source	Office of the Chief Knowledge Officer (OCKO), NASA/GSFC
URL	http://library.gsfc.nasa.gov/public/casestudies.htm
# of Pages	4
Abstract	Soon after the launch of Columbia STS-107, a piece of insulating foam struck the orbiter's left wing. Launch video did not reveal the extent of the damage, and engineers' analyses were inconclusive. The case follows the futile attempts of the chief structural engineer at Johnson Space Center to persuade upper management that obtaining images of Columbia's wing is critical to the safe return of ship and crew.
Subject Focus	Communication, organizational silence, hierarchical barriers
Learning Points	The struggle of voicing a dissenting opinion in a hierarchical and fast moving organization. The challenge of being heard in a matrix organization. The need for clear assignment of responsibility to special teams- What is their report and to whom? The personal struggles of an engineer in getting heard.
Other Resources	Harvard Case: "Columbia's Final Mission" (Multimedia Case) http://hbr.org/product/columbia-s-final-mission-multimedia-case/an/305032-MMC-ENG ; Columbia Accident Investigation Board (CAIB) Report: URL: http://caib.nasa.gov

Case Title	The Tour Not Taken - NASA's Comet Nucleus Tour (CONTOUR)
Project Name	CONTOUR
Source	NASA Safety Center (NSC)
URL	http://pbma.nasa.gov/docs/public/pbma/images/msm/CONTOUR_SFCS.pdf
# of Pages	4
Abstract	The Comet Nucleus Tour (CONTOUR) mission is a story of lost opportunities and incomplete communication. The spacecraft was developed to gain insight into the nature of comets. While in orbit, CONTOUR fired its motor to put itself on the trajectory toward its first comet. During this time, the team did not schedule telemetry coverage, but they expected to regain contact once the burn was over. After many attempts to reestablish communication with CONTOUR, the project team officially declared the spacecraft lost.
Subject Focus	on-orbit failure; team integration; faulty design
Learning Points	CONTOUR illustrates the value of integrating with contractors and other organizations on a project team. The mission also illustrates the need to identify programmatic risk and in this case, to identify mission-critical events and provide telemetry data for these events. Telemetry tracking is critical for understanding a failed mission.
Other Resources	Listed at the end of the case study document

Case Title	Thermosphere Ionosphere Mesosphere Energetics and Dynamics Project (TIMED) Case Study
Project Name	TIMED
Source	Academy of Program/Project & Engineering Leadership (APPEL), NASA
URL	http://www.nasa.gov/pdf/384153main_TIMED_case_study.pdf
# of Pages	21
Abstract	The TIMED mission was conceived around 1990 as a very ambitious multi-spacecraft mission. It was eventually launched on December 7, 2001 as a more modest mission with a single spacecraft. The program was caught in all the dramatic changes that NASA went through in this time period. At one point it came close to termination. The case study is presented in three distinct phases that characterize the development of the program.
Subject Focus	programmatic challenges; mission requirements; center buy-in; managing expectations; lines of authority; rules of engagement; complex relationships; personality conflicts
Learning Points	<p>Phase One Lessons Learned: 1) It is necessary to recognize and respond to ground rule changes in a timely manner; 2) Control expectations; 3) Center buy-in and cooperation is necessary; 4) Basic mission requirements must be set early, prioritized, and maintained.</p> <p>Phase Two Lessons Learned: 1) Building and employing an ETU for a new hardware development is still a good idea. Phase Three Lessons Learned: 1) Clear lines of authority and reporting are necessary and must be followed; 2) The rules of engagement must be agreed to and put into writing; 3) A clear decision on the method of implementation of a project must be made and the relationship of the program and project defined for that method; 4) The Center must take ownership of any project for which it has responsibility and staff it accordingly; 5) Management processes appropriate for NASA funded projects need to be in place, verified and used no matter where the project is developed; 6) It is necessary to adhere to the processes developed for integrating and testing a spacecraft; 7) Co-manifesting multiple missions on the same launch vehicle is still an appropriate cost-saving technique but it should be employed within one Enterprise only; 8) Personality conflicts can be real and should be addressed and resolved to assure efficient functioning of the project team.</p>
Other Resources	TIMED Mission website: http://www.timed.jhuapl.edu/WWW/index.php

Case Title	Vegetation Canopy Lidar
Project Name	VCL
Source	Academy of Program/Project & Engineering Leadership (APPEL), NASA
URL	http://www.nasa.gov/pdf/384157main_VCL_case_study.pdf
# of Pages	12
Abstract	The Vegetation Canopy Lidar (VCL) was selected in March 1997 as the First Earth System Science Pathfinder (ESSP) spaceflight mission. It was scheduled for launch in January 2000. Technology challenges (specifically with the Multi-Beam Laser Altimeter or MBLA) and project management challenges under the "PI-Mode" of mission management led to the mission being postponed indefinitely.
Subject Focus	weak project management & institutional oversight;
Learning Points	1) A formal process utilizing a team of independent recognized experts for reviewing and approving project proposals is crucial to assure that only viable proposals are submitted; 2) The project selection process must not stop at the desirability of the science being proposed. It must include the viability of the mission implementation plan as well; 3) Managers leading a proposal effort must address the above considerations as part of their proposal preparation process; 4) The project management of a fast-paced low-cost mission requires a strong, yet streamlined, central management structure with short communication paths; 5) The management of a fast-paced, low-cost project still requires the project discipline necessary to assure that the project meets its technical and programmatic objectives; 6) The above two lessons learned imply that an experience project manager is highly desirable for any fast-paced low-cost project; 7) Projects involving a U.S. government entity, such as a NASA Center, as a subcontractor to an outside PI must formally document their subcontracting relationship; 8) Independent cost estimates or assessments must be done in conjunction with independent technical and managerial reviews.
Other Resources	

Case Title	Wide-Field Infrared Explorer
Project Name	WIRE
Source	Academy of Program/Project & Engineering Leadership (APPEL), NASA
URL	http://www.nasa.gov/pdf/384167main_WIRE_case_study.pdf
# of Pages	16
Abstract	The Wide-Field Infrared Explorer (WIRE) was meant to study the formation and evolution of galaxies. Its delicate telescope was sealed inside a solid hydrogen cryostat. Shortly after launch, a digital error ejected the cryostat's cover prematurely. As a result, hydrogen discharged with a force that sent the Small Explorer craft tumbling wildly through space. The subsequent investigation identified several opportunities, in review and testing, to have caught the fatal design error. Why wasn't it caught? Senior managers provide their insights.
Subject Focus	"faster, better, cheaper" mandate; geographically dispersed teams; communications;
Learning Points	Lessons highlighted in the case study include the following: 1) The proper application of Field Programmable Gate Arrays; 2) The importance of proper peer reviews of critical mission subsystems and components; 3) The importance of effective closed-loop tracking of system and peer review action items; 4) Greater care is necessary when managing a project across major organizational boundaries; 5) Extra vigilance is required when deviating from full system end-to-end testing; 6) System designs must consider both nominal and off-nominal solutions.
Other Resources	

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www.nasa.gov